

## **METHOD FOR CHECKING THE EXISTENCE OF AN OPTICAL DISK USING A FOCUSING SIGNAL**

## **BACKGROUND OF THE INVENTION**

#### 1. Field of the Invention

The present invention relates to a method for checking the existence of an optical disk, and more specifically, but not by way of limitation, to a method for checking the existence of an optical disk by using the focus error signal or focus OK signal yielded by comparison 10 of a reference level with beam strength signal.

## 2. Description of the Related Art

FIG. 1 depicts a general optical disk drive system, comprising an optical pickup 2 for reproducing recorded signals from an optical disk 1, a sled motor 9 for moving the optical pickup 2 along the full length of the disk radius, a spindle motor 10 for rotating the optical disk 1, a drive unit 7 for driving the sled motor 9 and the spindle motor 10, an RF unit 3 for equalizing and shaping the RF signal reproduced from the optical disk 1 by the optical

pickup 2, a servo unit 5 for controlling the optical pickup 2 and drive unit 7 using the rotation speed of the optical disk 1 and focus and tracking error signals outputted from the optical pickup 2, a digital signal processing unit 4 for retrieving original digital data from the binary data stream outputted by the RF unit 3, a microcomputer 6 for supervising the operation of the servo unit 5 and digital signal processing unit 4, and a memory 8 for storing data needed for the operation of the microcomputer 6. The focus 10 error (FE) signal generated by the optical pickup 2 will be explained in detail with reference to FIGS. 2A to 2D.

FIG. 2A shows a focus error (FE) signal waveform generated by the optical pickup 2 in the case where no disk is contained in the disk tray of the optical disk drive.

15 Since the incident laser beam is not reflected, the focus error signal is irregular and contaminated by a significant amount of noise, the level of the focus error signal being much lower than a prescribed reference level Ref1a.

FIG. 2B shows a focus error signal waveform generated 20 by the optical pickup 2 when an optical disk has been inserted into the disk tray. In this case, the focus error signal is of a sinusoidal waveform and the level is greater than the reference level Ref1a, the amount of noise being relatively small.

25 FIG. 2C shows a focus error signal waveform generated by the optical pickup 2 in the case where the disk tray contains an optical disk of a low reflection ratio such as a rewritable optical disk. The general shape of the focus error signal is similar to that in FIG. 2B, but the level 30 of the focus error signal is lower because of the low reflection ratio of the optical disk. Therefore, it is likely that the level of the focus error signal does not exceed the reference level Ref1a and the existence of the

optical disk is not detected. To solve this problem, the reference level should be lowered enough to detect the optical disk with a low reflection ratio.

If a low reference level Ref1b is employed, an optical disk with a low reflection ratio can be detected as long as the level of the focus error signal exceeds the low reference level Ref1b. In this case, however, it is possible that the level of the focus error signal obtained in the case of no disk goes up the reference level Ref1b as shown in FIG. 2D, which leads to a wrong disk detection result.

#### SUMMARY OF THE INVENTION

It is an object of the present invention to provide a method for checking the existence of an optical disk using focus OK signal that prevents misjudgment caused by noise contained in focus error signal.

It is another object of the present invention to provide a method for checking the existence of an optical disk by comparing sum of focus error of which the level is less than a prescribed reference level with another reference level.

The method for checking the existence of an optical disk using focusing signal in accordance with an embodiment of the present invention comprises examining whether a focus OK signal is asserted while moving an optical pickup in the direction of the place where an optical disk is placed, starting detection of the value of focus error if said focus OK signal is asserted, and judging the existence of an optical disk, depending upon the magnitude of detected value.

The method for checking the existence of an optical

disk using focusing signal in accordance with another embodiment of the present invention comprises examining whether the peak of focus error signal exceeds a predefined reference level, while moving an optical pickup in the 5 direction of the place where an optical disk is placed, detecting and summing the magnitude of focusing signal after the peak is detected, and judging the existence of an optical disk, depending upon the magnitude of the sum value.

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BRIEF DESCRIPTION OF THE DRAWINGS

10 The accompanying drawings, which are included to provide a further understanding of the invention, illustrate the preferred embodiments of the invention, and together with the description, serve to explain the principles of the present invention.

15 In the drawings:

FIG. 1 is a block diagram for an optical disk drive;

FIGS. 2A to 2D are several focus error signal waveforms measured under various environments;

20 FIG. 3 is a block diagram of an optical disk drive embodying the present invention;

FIG. 4 is waveforms of important signals used by the method for checking the existence of an optical disk in accordance with an embodiment of the present invention;

25 FIG. 5 is a flowchart of the method for checking the existence of an optical disk in accordance with an embodiment of the present invention;

FIGS. 6A to 6C are waveforms of focus OK signal and focus error signal obtained when a disk exists and does not;

30 FIGS. 7A to 7C are waveforms of focus error signal used by the method for checking the existence of an optical

disk in accordance with another embodiment of the present invention; and

FIG. 8 is a flowchart of the method for checking the existence of an optical disk in accordance with another embodiment of the present invention.

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*u/d* DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

In order that the invention may be fully understood, preferred embodiments thereof will now be described with reference to the accompanying drawings.

10 FIG. 3 shows an optical disk drive embodying the present invention, comprising an optical pickup 2 for reproducing recorded signals from an optical disk 1, a sled motor 9 for moving the optical pickup 2 along the full length of the disk radius, a spindle motor 10 for rotating 15 the optical disk 1, a drive unit 7 for driving the sled motor 9 and the spindle motor 10, an RF unit 3 for equalizing and shaping the RF signal reproduced from the optical disk 1 by the optical pickup 2 and for creating a focus OK (FOK) signal, a servo unit 5 for controlling the 20 optical pickup 2 and drive unit 7 using the rotation speed of the optical disk 1 and focusing and tracking error signals outputted from the optical pickup 2, a digital signal processing unit 4 for retrieving original digital data from the binary data stream outputted by the RF unit 3, 25 an A/D converter 11 for digitizing the focus error signal from the optical pickup 2, a microcomputer 6 for supervising the operation of the servo unit 5 and digital signal processing unit 4 and for checking the existence of an optical disk using the digitized focus error signal and 30 the focus OK (FOK) signal, and a memory 8 for storing data needed for the operation of the microcomputer 6.

11 FIG. 4 shows the waveforms of four important signals  
used by an embodiment of the present invention for checking  
the existence of an optical disk. The first signal is the  
focus drive signal corresponding to the focus control  
5 signal (FCS) created by the servo unit 5. The second signal  
is the beam strength signal (BS) outputted by the optical  
pickup 2 while the objective lens moves in response to the  
focus drive signal. In a 3-beam optical pickup, the sub-  
beam-added signal is generally used as the beam strength  
10 signal. In a 1-beam optical pickup, however, the beam  
strength signal is derived from the filtered RF signal. The  
third signal is the focus OK (FOK) signal created by  
comparison the beam strength (BS) signal and a predefined  
reference signal C1 set low enough to detect the existence  
15 of a rewritable optical disk. The last signal is the focus  
error signal. The method for checking the existence of an  
optical disk using these signals will be explained in  
detail with reference to the block diagram in FIG. 3 and a  
flowchart shown in FIG. 5.

20 When the disk tray closes or at power-on of the  
optical disk drive (S1), the microcomputer 6 initializes a  
sum variable (S2) and starts focus search. In response to  
the focus search command, the servo unit 5 outputs the  
focus control signal to move the objective lens. The RF  
25 unit 3 generates the focus OK (FOK) signal by comparing the  
beam strength (BS) signal with a predefined reference level  
C1.

27 13 The microcomputer 6 examines the state of the focus  
OK (FOK) signal (S3) and starts A/D conversion of the focus  
30 error signal if the focus OK signal is asserted (S4).  
Therefore, A/D conversion of the focus error signal is  
performed only while the level of the focus OK signal is  
high, as shown in FIG. 6A. Then, the microcomputer 6 adds

the digitized focus error to the sum variable only if the digitized error exceeds a predetermined reference level  $C_{MIN}$  (S5).

Finally, the microcomputer 6 compares the sum value 5 with a predetermined level set for disk detection (S6) and concludes that an optical exists if the sum value is greater than the predetermined level (S7).

Even when an optical disk does not exist, the focus error signal may exceed the reference level  $C_{MIN}$  because of 10 noise as shown in FIG. 6B. In this case, however, the focus OK (FOK) signal is not asserted and therefore the focus error signal is not digitized, which makes the sum variable remain unchanged. Consequently, the microcomputer 6 concludes no disk to exist (S8) and misjudgment due to 15 noise is prevented.

The focus OK signal might be asserted by a burst noise as shown in FIG. 6C. In this case, however, the duration of the high state of the focus OK signal is relatively short compared to that created in a normal 20 situation. Since the focus error signal is sampled only during the short interval, the sum of the sampled focus error is likely to be lower than the predefined level. In addition, even if the duration of the asserted focus OK signal is long, the sum of the sampled focus error is not 25 likely to exceed the level because the focus error signal is generated only by noise.

As a result, the existence of an optical disk can be checked with no misjudgment by sum of the digitized focus error sampled only while the focus OK signal is asserted, 30 despite the existence of noise.

FIGS. 7A to 7C show focus error signal waveforms used by another embodiment of the present invention. FIG. 7A shows a typical waveform of normal focus error signal

obtained when an optical disk exists in the disk tray. It is seen that the peak level of the focus error is greater than a high reference level  $C_{U_{MIN}}$  as well as than a low reference level  $C_{L_{MIN}}$ .

5 FIG. 7B shows an example waveform of the focus error signal generated by a rewritable optical disk. Owing to the low reflection ratio of the rewritable optical disk, the peak level of the focus error is greater than the low reference level  $C_{L_{MIN}}$  but less than the high reference level  
10  $C_{U_{MIN}}$ .

FIG. 7C shows an example waveform of the focus error signal obtained when no disk is contained in the disk tray. It is seen that the focus error signal is irregular and seriously contaminated by noise and the peak value may  
15 exceed the low reference level  $C_{L_{MIN}}$ , without exceeding the high reference level  $C_{U_{MIN}}$ .

For correct detection of the existence of an optical disk, therefore, the difference of the two waveforms shown in FIGS. 7B and 7C should be discerned. Such discrimination  
20 can be achieved by using the focus error signal lower than the low reference level  $C_{L_{MIN}}$ . The sampled focus error of which the level is lower than the low reference level  $C_{L_{MIN}}$  is added and compared with a predefined reference level since the signal below the low reference level  $C_{L_{MIN}}$  is  
25 insensitive to a noise. Table 1 gives the added absolute values obtained by experiments in each case.

【Table 1】

	Rewritable disk		No disk	
	Above zero (+)	Below zero (-)	Above zero (+)	Below zero (-)
1	898Eh	6122h	5FA7h	0000h
2	8B23h	530Fh	86BFh	0000h

3	6B70h	66C7h	8D08h	0000h
4	7232h	63D3h	7420h	0000h
5	7790h	63B4h	88A0h	0000h
6	908Eh	5CBAh	7D09h	0000h
7	66e6h	6302h	72F2h	0000h
8	870Dh	6666h	7D27h	0000h
9	8D0Bh	561Ch	6F1Eh	0000h
10	8495h	5A8Ah	7156h	0000h

h = hexadecimal

It is shown that in the case of an optical disc with a low reflection ratio, the sum of the absolute values of focus error less than the low reference level  $C_{LMIN}$  is much greater than 0, whereas in the case of no disk, the sum value is near 0. This fact implies that the two cases can be clearly discriminated if an appropriate reference level between the two sum values is chosen. The method in accordance with another embodiment of the present invention is explained in detail with reference to FIG. 8.

When the disk tray closes or at power-on of the optical disk drive (S10), the objective lens moves upward to find focus point (S11). The microcomputer 6 digitizes the focus error signal at a constant rate, detects the peak point, and compares the peak level with a high reference level  $C_{UMIN}$  (S12). Only when the peak level is greater than the high reference level  $C_{UMIN}$ , the microcomputer 6 samples the focus error signal for a given time duration (S13) after the peak is detected. And the microcomputer 6 adds the absolute values of the sampled focus error of which the level is lower than a low reference level  $C_{LMIN}$  (S14) and then compares the sum value with a predefined value (S15). If the sum value is less than the predefined value, the